Who Benefits from Cheap Wood?

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I. Introduction and Summary

The purpose of this study is to analyze the distributional impact among U. S. households of supply induced changes in timber product prices. The allocation of forest resources among competing uses (timber production, mining, recreation, wildlife preservation and water resource maintenance) and the intensity of investment in growing timber have significant effects on the supply of timber to U.S. markets. Conditions of supply -- which are influenced significantly by policy of the U.S. Forest Service -- interact with domestic and international demand in determining the prices which U. S. households face for a wide variety of commodities that utilize timber products. This study does not attempt to ascertain the relationship between supply and price, but rather considers the impact on households resulting from a given change in wood-product prices.

Briefly the methodology is as follows. An increase in price at the logging industry level is traced through an input-output matrix to changes in the prices of commodities that households purchase. The impact on consumers of the higher prices is evaluated and summary statistics are presented which compare the impact on certain categories of households. Particular attention is paid to the influence of household income and home ownership on the magnitude of impact.

The principal results can be briefly summarized:

1. Households which do not own their residency are substantially more affected by changes in the prices of forest products than are home owners.

2. Apart from the impact of changes in housing prices, the impact of changing wood prices for other commodities is slightly less than proportional to the household income.

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3. Because homeowners are concentrated in higher income classes, the total impact of an increase in timber prices is somewhat smaller, as a proportion of income, for high income households than for low income households. On the other hand the benefit of a reduction in timber prices is larger, as a proportion of income, for low income households than for high income households.

Section II describes the use of the input-output matrix to estimate changes in the prices of final demand commodities. Additional documentation on this aspect is also presented in Appendix A. Section III discusses the method of evaluating the impact on households of price changes. Section IV presents the empirical results. Additional documentation on the household data is presented in Appendix B. Section V concludes this study with a review of the principal results and a discussion of certain limitations on their applicability.

II. Price Increases of Final Demand Commodities

A change in the conditions of timber supply interacts with given conditions of demand for timber and its substitutes, altering the prices of many commodities in the economy. Ideally one would wish to relate a policy instrument, such as the quantity of timber supplied from federal lands, to a vector of prices at which all markets in the economy are in equilibrium. Once the effect of policy changes on equilibrium prices is known, then the methodology of Section III would allow an evaluation of the distributional consequences of such policy changes.

This study is only an approximation to that ideal. First we have not examined the relationship between policy variables and the equilibrium price

of timber. A considerable amount of work has been done previously on this subject.[1] Instead we have begun by assuming that a policy change has already resulted in a given change in the price of timber.

Second our analysis of changes in prices which households face, given a change in the price of timber, ignores the possibility of factor substitution in production. What is captured by the analysis is the extent to which timber products contributed to the value of various commodities at a particular set of prices, in this case those of 1967. Commodities which utilize large amounts (in value terms) of timber products in their production are more affected by increases in the price of timber than are commodities which utilize small amounts of timber products.

The input-output table is one means of capturing these relationships. Each entry of the table gives the amount of a particular input "necessary" for (or, more specifically, the amount actually used in) the production of a unit of a particular output. Such a table incorporates both the direct utilization of timber and the indirect utilization of timber in intermediate products.

The input-output table used in this paper is derived from the Department of Commerce study for 1967 (USDC, 1974). To begin with, an increase in the price of the logging sector output was assumed. The input-output coefficients were then used to compute increases in the prices of outputs in 56 sectors which sell commodities to households, where those sectors vary in the direct and indirect utilization of wood.

The principal advantage of the input-output approach is its ability to capture the complex interactions of primary, intermediate and final demand commodities. Its disadvantages are three. First the technological rela-

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tionships of production are assumed to be fixed over time. This assumption is not too onerous for a horizon of a few years. However over a longer period of time technological change is likely to be induced by changes in timber prices. Second the fixed production relationships do not allow for substitution between inputs as prices change. Even with a given state of technological knowledge, it is likely that substitution possibilities exist -- for example plastic for paper bags or steel for wooden beams. Third as industries attempt to make these substitutions, the prices of other raw materials will generally be affected. These price changes in turn have effects on the prices of commodities households purchase.

In summary a given change in the price of logging sector output has been translated into changes in the prices which households pay for the commodities they purchase. It should be noted that the linearity of the input-output structure insures that the magnitude of the initial price change is not of importance for our purposes; a doubling of the initial price change implies exactly a doubling of the resulting changes in prices to households.

III. The Impact of Price Changes on Households

Human welfare is not subject to direct measurement nor are comparisons between individuals always appropriate. Nevertheless economic theory provides a model of consumer behavior within which the concept of a welfare impact can be given a precise meaning. While the economic model is highly simplified and abstract, it does provide a useful guide to the evaluation of the effects of price increases and is adopted in this study for that purpose. The

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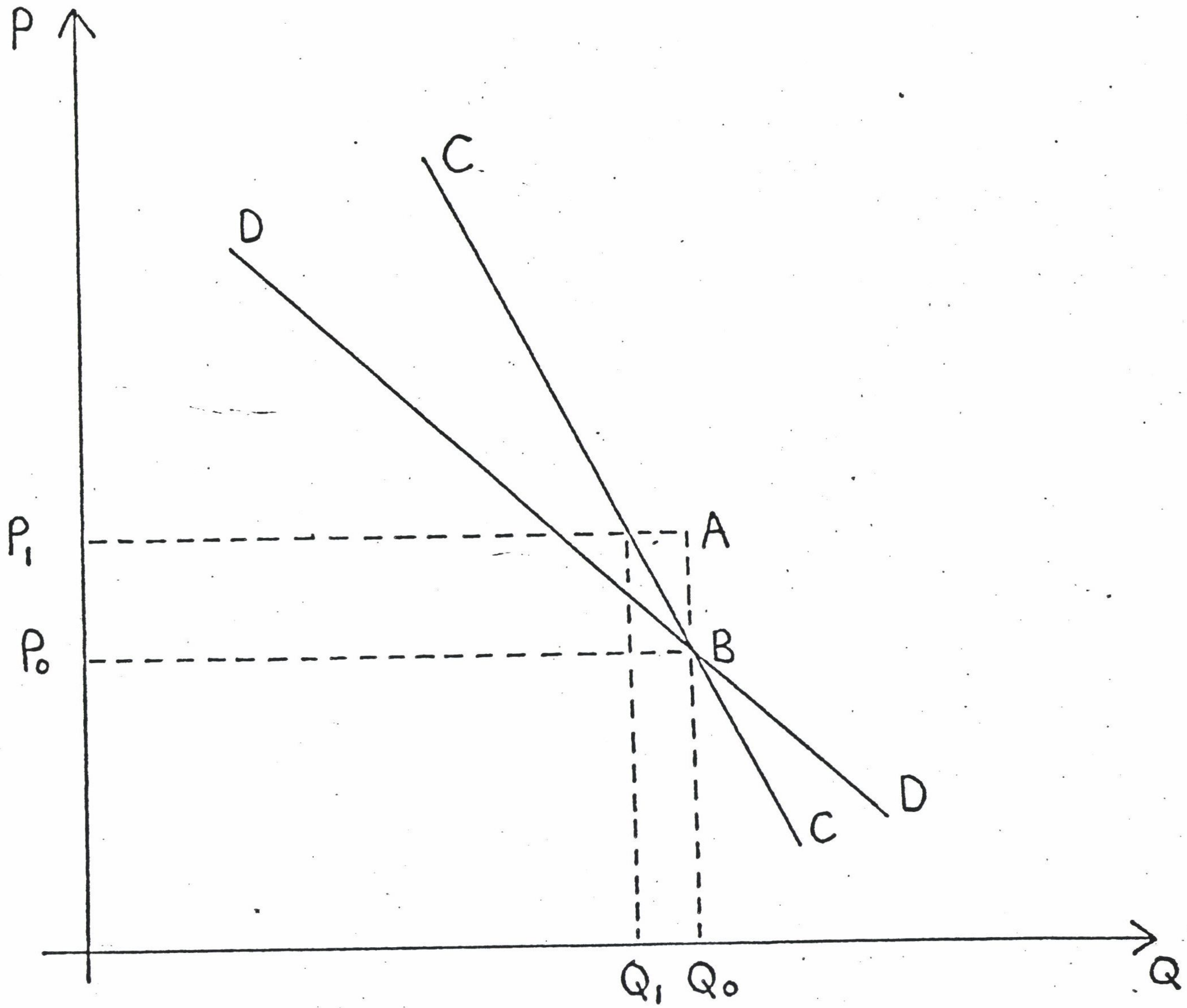
statement "Household k is made worse off by \$y" as the result of a price increase means that if household k were given an unconditional grant of \$y, then the household would be exactly as well off as it was prior to the price increase.

To illustrate the point, consider the diagram labeled figure 1. The quantity of a particular good is measured along the horizontal axis and the price of that good on the vertical axis. The downward sloping line DD represents the quantity a particular household wishes to purchase as a function of the commodity's price, all other things held constant. This is the familiar demand curve. At the initial price P_o the household purchases Q_o, as shown. The line CC passing through the original position (P_o, Q_o) is the "income compensated" demand curve. For every price P this curve shows the quantity that would be purchased if the household were given a cash grant just large enough to make it as well off (but not better) than before the price change. In general the income compensated demand curve is not vertical; that is, it is not necessary to provide the household with a cash grant that would actually enable it to purchase exactly the same bundle of goods as before the price change. Rather the necessary grant (\$y) is less than $(P_1-P_o)Q_o$ because the household can substitute consumption of other commodities for Q. Substitution is generally desirable because the prices of all other commodities relative to Q have decreased; the household chooses a new consumption point (under the compensation assumption) $Q_1 < Q_o$.[2]

Thus the compensating grant (\$y) provides a well defined measure of the impact on a household of the increase in the price of a commodity.[3,4] Unfortunately it is not observable nor even inferrable from actual behavior in response to a price change. In this study the welfare impact is measured

Figure 1



The Demand Curve (DD), Compensated Demand Curve (CC), and the Measure of Impact (P_1ABP_0)

as the change in price times the original quantity, ΔPQ_o.[5] As noted above this measure is an upper bound to the actual impact. If there exist no possibilities for substitution between goods, then the measure is exact (in the sense that it is exactly the magnitude \$y -- see footnote 3).

A further theoretical difficulty arises because this study changes all prices simultaneously while the above analysis assumed that all other prices but that for a single commodity are held constant. The sign of the bias introduced in this way cannot be determined _a priori_. However in the case of all prices rising in proportion, ΔPQ_o would be the exact measure of the theoretical impact since no gain at all could be made from altering the composition of the consumption bundle.

The operational measure of the total impact on a household is then the sum of the measured impacts derived from the change in price of each commodity. The consumer expenditure data show, for each household k and commodity j, the amount of money spent on that commodity. Denote this magnitude by $E_{jk} = P_j Q_{jk}$. In accordance with the notation of Appendix A denote the percentage change in the price of the j^{th} commodity as $B^*_{i'j}$. Then the measured impact on a household is given by the sum, over all commodities, of the product of the B* and E terms.

$$\text{(1)} \qquad IMP1_k = \sum_j (E_{jk} B^*_{i'j})$$

A special case arises in consideration of expenditures for housing. Unlike most other consumer goods, a large stock of housing is already in existence and the service flow derived from this stock will continue for many years. This study assumes that the price of existing housing changes in exactly the same proportion as the price of new housing. Increased costs

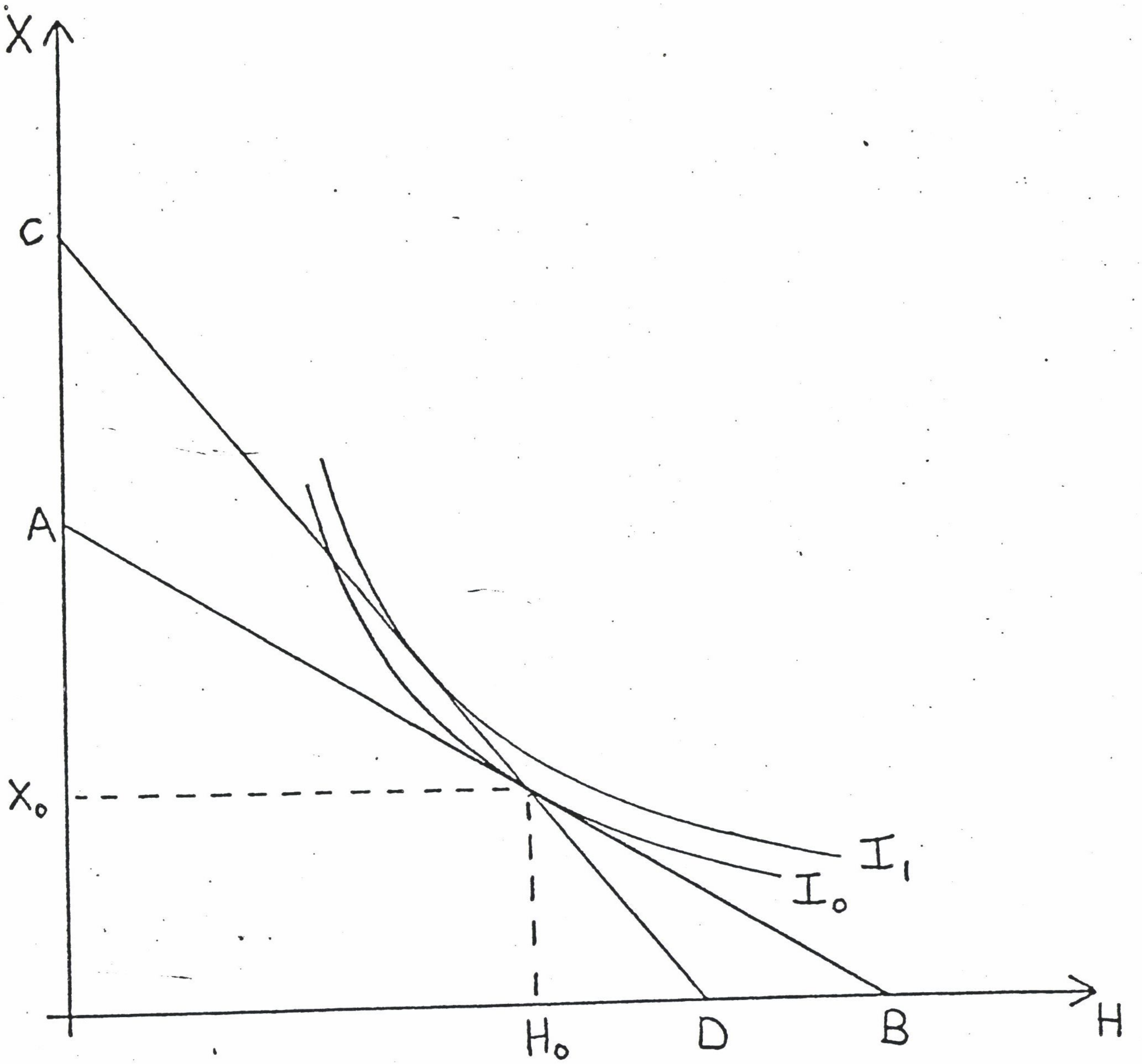
for new housing will tend to increase the demand for existing houses until the costs of residing in each are the same.

It follows that the owners of present housing may realize a capital gain by the sale of their houses. However, since the cost of housing has increased no real benefit would accrue from the sale. The situation is illustrated in Figure 2. The horizontal axis measures the "quantity" of housing and the vertical axis represents all other goods. Initially a homeowner purchases H_0 units of housing and X_0 units of all other goods; these quantities allow the homeowner to reach the highest indifference curve touching the budget line denoted by AB. After the price of housing increases the new budget line for a homeowner is given by CD. It passes through the point (H_0, X_0) because the homeowner may choose simply to continue to reside in the same house and purchase the same quantity of other goods. The diagram shows that in general some substitution of other goods for housing would benefit the homeowner; the new optimum is to the left of H_0 and indicated by the tangency of I_1 with CD. However this substitution is of exactly the same nature as that which is ignored for other commodities in measuring the impact as ΔPQ_o. For other commodities ΔPQ_o overstates the (negative) impact; for homeowners, measuring the impact as zero is also a negatively biased overstatement. For consistency, then, the impact on homeowners of the increased cost of housing is also taken to be zero. For renters, the measured impact is exactly as for all other commodities, ΔPQ_o (Figure 1).

IV. Empirical Results

The section above discussed the methodology for measuring the impact on households of changes in commodity prices. In this section the results

Figure 2



Effect of an Increase in the Price of Housing

on the Homeowner

of the calculations are examined. The data on household expenditures are derived from the 1960 Survey of Consumer Expenditures by the Bureau of Labor Statistics. For details see Appendix B.

Each of the Tables I-VI contains four entries in a column. The first row is an estimate of the percentage of households in the U. S. in 1960 that belonged to the category that defines the cell. The second, third and fourth rows involve three measures of impact: the second row is an estimate of the mean value of the impact measure for households in the category defining the cell. The third row is an estimate of the mean value of the impact as a percentage of after-tax income for households in the category defining the cell. The fourth row is an estimate of the mean value of the impact as a percentage of household consumption expenditures for households in the given category.

There are several reasons for including the last row. Economic welfare results primarily from consumption of goods and services and leisure. A higher money income, per se, does not imply an increase in welfare. Only when that income is translated into goods and services does the household benefit. Consumption therefore is perhaps a better measure of the welfare actually attained. Secondly, money incomes vary much more from year to year than do consumption expenditures. Households that encounter temporary variations in their income due to unemployment, illness or other factors tend to alter their consumption expenditures by less than if the changes in income were permanent. In the short run this involves saving and dissaving to meet current cash flow needs. The relative stability of consumption expenditure as compared to money income suggests that the former is a better proxy for permanent income and economic welfare than the latter.

TABLE 1

IMPACT, VARIANT 1, BY INCOME CLASS

Income $\$10^3$	0-1	1-2	2-3	3-4	4-5	5-6	6-7.5	7.5-10	10-15	15-25	> 25	All
% Household	4.65	13.6	13.2	12.5	13.5	12.2	13.6	10.9	4.5	.75	.19	100.0
IMP1	5.67	9.53	13.5	17.4	20.2	22.5	24.9	29.4	37.2	48.3	60.3	19.8
IMP1/Y (%)	1.17	.63	.54	.49	.44	.40	.37	.34	.32	.27	.19	.49
IMP1/C (%)	.56	.57	.52	.49	.47	.44	.41	.39	.38	.37	.34	.47

INCOME is after tax household income.

% HH is the percentage of households tabulated belonging to each category.

IMP1 is the measure of impact on househols, variant 1, average for each category.

IMP1/Y is the measure of impact as a percentage of INCOME, average for each category.

IMP1/C is the measure of impact as a percentage of household consumption expenditures, average for each category.

Throughout the discussion of the empirical results we make frequent reference to whether or not estimates of the impact increase more or less than proportionally to income or consumption expenditure. We wish to emphasize that the standard of proportionality is purely descriptive; there is no intention of suggesting that one relationship is more just or correct in an ethical sense. Rather, the positive standard of proportionality is a means of measuring relative impacts; the reader is left free to apply his or her own normative standards to the calculations.

In Table I households are classified solely on the basis of income class.

a. Average impacts (row 2) increase monotonically with income class; the average impact in the greater than $25,000 class is about six times the impact in the $1000-$2000 class.

b. Row 3, the average ratio of impact to household income (as a percentage), declines as income class increases; the percentage is about three times as large in the next to the lowest class than it is in the highest class (.63 vs. .19).

c. Row 4, the average ratio of impact to household consumption expenditures (as a percentage), also declines as income class increases; the decline, however, is not so marked as in row 3.

Table II presents the same calculations as Table I except that a slightly different measure of impact, IMP2, is used. The impact measure IMP1 developed in Section III assumes that the compensated demand curve for each commodity is vertical, that is, has zero elasticity with respect to price. In order to test the sensitivity of the results to this assumption an alternative specification of minus 1. is used for the elasticity.

TABLE II

IMPACT, VARIANT 2, BY INCOME CLASS

Income-10^3	0-1	1-2	2-3	3-4	4-5	5-6	6-7.5	7.5-10	10-15	15-25	> 25	All
% Household	4.65	13.6	13.2	12.5	13.5	12.2	13.6	10.9	4.5	.75	.19	100.0
IMP2	5.56	9.41	13.4	17.2	19.9	22.2	24.7	29.0	36.9	47.9	59.7	19.6
IMP2/Y (%)	1.15	.62	.53	.49	.44	.40	.37	.34	.37	.26	.18	.48
IMP2/C (%)	.56	.56	.51	.49	.46	.43	.40	.39	.38	.37	.34	.47

INCOME is after tax household income.

% HH is the percentage of households tabulated belonging to each category.

IMP2 is the measure of impact on households, variant 2, average for each category.

IMP2/Y is the measure of impact as a percentage of INCOME, average for each category.

IMP2/C is the measure of impact as a percentage of household consumption expenditures, average for each category.

Let the compensated demand C_{kj} of the kth household for the jth commodity be given by

(2) $$C_{kj}(P_j) = C^o_{kj} P^{-1}_j$$

where C^o_{kj} is a constant. Then expenditure on the jth commodity at the initial price P^o_j is given by

(3) $$E_{jk} = C_{kj}(P^o_j) \cdot P^o_j = C^o_{kj}$$

The area under the compensated demand curve between initial and final prices is

(4) $$IMP2_{kj} = \int_{P^o_j}^{P^1_j} C_{kj}(P_j)dP_j$$

$$= C^o_{kj} \int_{P^o_j}^{P^1_j} (1/P_j)dP_j$$

$$= C^o_{kj}[\ell n\ P^1_j - \ell n\ P^o_j]$$

$$= C^o_{kj}\ \ell n\ (1 + \Delta P_j/P^o_j)$$

Using (3), the fact that the percentage increase in price is given by $B^*_{i'j}$, and summing over all commodities, we obtain

(5) $$IMP2_k = \sum_j [\ell n\ (1. + B^*_{i'j}) \cdot E_{jk}]$$

The results displayed in Table II are very similar to those in Table I, and hence do not seem to be sensitive to the exact parameterization of the compensated demand curve.

Table III classifies households by both income class and age of the head of household. Entries in each cell of Table IV have the same meanings as in Table I and II. The impact measure used in this and each of the following tables is IMP1.

The purpose in controlling for age is to insure that the observed pattern of impacts is not a spurious result of correlations among consumption expenditure, income and age. Most households have a lifetime pattern of income which increases through approximately ages 40-60, and then flattens out or declines. In most cases individuals correctly foresee this income-age pattern, and adjust their consumption-age pattern accordingly. Students, for example, often spend far greater amounts than are sustainable by their current incomes, because they recognize that their future incomes will be substantially larger. Retired persons similarly consume more than is warranted by current income, in the process running down assets accumulated during the years of high income.

The impact measures used in this study are calculated from observed consumption expenditures. It is theoretically possible that the patterns revealed in Table I were the result of the very young and the very old being concentrated in the low income classes while at the same time having a high level of consumption expenditure relative to income. The results displayed in Table III, however, are much the same as in Table I: Holding age constant impacts are increasing with income class, and the ratios of impact to income and consumption expenditures decline with class.

The "ALL" column indicates that the impact declines with age. However this effect is offset by a lowering of average incomes for households with

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TABLE III

IMPACT, VARIANT 1, BY AGE AND INCOME CLASS

Income-$$10^3$

Age	0-1	1-2	2-3	3-4	4-5	5-6	6-7.5	7.5-10	10-15	15-25	> 25	ALL
< 25	* 16.5 3.09 .85	* 11.9 .75 .67	* 15.6 .61 .62	* 21.6 .60 .60	* 24.2 .52 .54	* 30.8 .55 .57	* 34.4 .51 .55	* 38.0 .46 .53	* 24.4 .18 .40	* 42.6 .22 .71	.00 - - -	4.1 22.8 .61 .59
25-34	* 5.0 .62 .50	* 12.1 .72 .62	1.5 16.0 .62 .59	2.1 20.3 .57 .55	3.2 22.7 .49 .50	2.8 25.1 .45 .46	2.7 27.6 .41 .44	1.6 33.6 .39 .44	* 37.6 .33 .39	* 52.8 .30 .54	* 42.2 .11 .42	15.5 24.0 .49 .50
35-44	* 7.5 3.00 .45	* 10.3 .63 .56	1.6 14.5 .56 .51	2.1 18.7 .52 .50	2.8 21.1 .45 .47	3.0 22.2 .39 .42	4.3 24.6 .36 .39	3.4 29.6 .34 .39	1.2 40.2 .34 .40	* 46.0 .25 .36	* 58.3 .18 .33	19.9 23.6 .44 .44
45-54	* 6.3 2.47 .54	1.3 11.0 .72 .61	2.0 14.0 .54 .52	2.1 16.8 .48 .46	2.4 19.0 .41 .43	2.6 21.1 .38 .40	3.3 24.4 .35 .39	3.1 28.0 .32 .37	1.5 37.2 .31 .37	* 46.2 .25 .34	* 67.8 .22 .32	19.4 22.0 .46 .43
55-64	* 5.9 1.01 .58	2.3 9.1 .59 .54	2.2 12.6 .50 .49	1.8 16.1 .45 .46	2.4 17.6 .39 .43	1.8 19.3 .35 .40	1.8 21.8 .32 .37	1.7 28.4 .33 .39	* 34.7 .29 .37	* 45.5 .25 .34	* 59.8 .17 .33	16.3 17.9 .45 .45
65-74	1.3 5.3 .71 .56	4.6 9.0 .60 .54	3.4 12.8 .51 .50	2.6 14.7 .42 .44	1.5 17.4 .39 .43	1.0 20.6 .37 .44	* 21.3 .32 .37	* 25.0 .29 .37	* 33.3 .28 .37	* 56.8 .31 .40	* 67.1 .20 .33	16.6 14.1 .49 .48
≥ 75	1.5 5.1 1.01 .56	2.9 8.4 .58 .56	1.6 11.1 .45 .46	* 13.9 .40 .46	* 16.8 .37 .43	* 18.4 .33 .42	* 27.0 .37 .47	* 25.1 .32 .40	* 34.0 .28 .36	* 71.8 .35 .51	* 33.7 .10 .23	7.9 10.8 .59 .51

*Indicates less than 1%.

TABLE IV

IMPACT, VARIANT 1, BY TENURE AND INCOME CLASS

Income-$\$10^3$	0-1	1-2	2-3	3-4	4-5	5-6	5-7.5	7.5-10	10-15	15-25	> 25	All
Owner	2.13	5.90	5.96	5.74	6.56	7.11	9.48	8.00	3.50	*	*	55.21
	4.1	6.50	9.5	12.4	14.9	17.4	21.1	25.4	32.9	45.0	60.3	17.3
	1.1	.42	.37	.35	.32	.31	.31	.29	.28	.25	.18	.36
	.37	.36	.36	.35	.34	.34	.34	.34	.34	.34	.33	.35
Renter	2.47	7.54	6.98	6.47	6.48	4.59	3.55	2.44	*	*	*	41.55
	6.9	11.8	16.7	21.7	25.2	29.3	34.5	40.5	51.7	68.0	77.3	22.5
	.94	.78	.66	.61	.55	.53	.51	.47	.43	.36	.28	.63
	.72	.73	.65	.61	.58	.56	.55	.55	.50	.52	.51	.62
Other	*	*	*	*	*	*	*	*	*	*	*	3.24
	8.6	11.1	17.6	19.7	22.3	29.4	29.1	37.0	47.9	63.4	24.1	26.4
	15.4	.70	.70	.55	.47	.52	.43	.42	.41	.33	.03	.73
	.48	.54	.56	.46	.46	.50	.44	.46	.48	.49	.37	.48

*Indicates less than 1%.

older heads and hence the ratio measure describes a slightly "U" shaped curve. This is to be expected since both the very young and the very old tend to spend a high proportion of their incomes, while most savings are generated in the middle years. It is somewhat surprising, therefore, that expressing the impact as a percentage of consumption does not alter the results. It appears that changes in saving behavior are insignificant relative to the correlation between age and income. Therefore as age increases from the young to middle years, income increases to its maximum value. Since the impact as a percentage of either income or expenditure is lowest at the highest incomes, the graph of percentage impact versus age reaches its lowest point in the middle age groups.

Table IV displays the calculations for households classified by owner-renter status. "Owner" means that the household owned its principal residency during all of the survey year. "Renter" means the household rented during all of the survey year. All other households fall into the "other" category. The measure of impact is again IMP1.

Within the owner classification the estimated ratio of impact to consumption expenditures is almost constant. Within the renter classification the estimated ratios of impact to income (row 3) and consumption (row 4) still decline substantially as income class increases. The most striking feature of the table is that within income classes the impact on renters is about 60% larger than on owners. The "ALL" column indicates that the ratio measures are about 70% larger for renters than for owners. It is apparent that a key determinant of the impact of changing wood prices is renter-owner status, with renters uniformly more affected by increases in timber prices.

It also appears that within tenure classifications impacts are closer to being proportional to income and consumption expenditures. This aspect is considered further in the discussion of Table VI.

Tables V(a & b) classify households by age, tenure, and income class. The purpose, as with Table III, is to insure that the patterns revealed in Table V are not caused by spurious influences of age. (Asterisks in this table indicate less than an estimated 0.1% of U. S. households fall into the category which defines the cell. The other values in the cell should be regarded with caution since they were calculated from relatively few observations.) In general the results in Tables V(a & b) are consistent with those in Table IV.

To obtain more precise estimates of the relationships suggested in Tables I-III, -- between impact, on one hand, and age and income on the other -- six regression models are specified. The models and estimates of the parameters are summarized in Table VI.

$$\text{(1A)} \quad \ell n\text{IMP1} = \text{const} + \alpha_1\,\text{AGE} + \alpha_2\,\text{AGE}^2 + \beta_1\,\ell n\text{Y} + \varepsilon$$

$$\text{(1B)} \quad \ell n\text{IMP1} = \text{const} + \alpha_1\,\text{AGE} + \alpha_2\,\text{AGE}^2 + \beta_1\,\ell n\text{Y} + \gamma_1 E_1 + \gamma_2 E_2 + \varepsilon$$

$$\text{(1C)} \quad \ell n\text{IMP1} = \text{const} + \alpha_1\,\text{AGE} + \alpha_2\,\text{AGE}^2 + \beta_1\,\ell n\text{Y} + \beta_2 B_1 + \beta_3 B_2 + \gamma_1 E_1 + \gamma_2 E_2 + \varepsilon$$

$$\text{(2A)} \quad \ell n\text{IMP1} = \text{const} + \alpha_1\,\text{AGE} + \alpha_2\,\text{AGE}^2 + \beta_1\,\ell n\text{C} + \varepsilon$$

$$\text{(2B)} \quad \ell n\text{IMP1} = \text{const} + \alpha_1\,\text{AGE} + \alpha_2\,\text{AGE}^2 + \beta_1\,\ell n\text{C} + \gamma_1 E_1 + \gamma_2 E_2 + \varepsilon$$

$$\text{(2C)} \quad \ell n\text{IMP1} = \text{const} + \alpha_1\,\text{AGE} + \alpha_2\,\text{AGE}^2 + \beta_1\,\ell n\text{C} + \beta_2 D_1 + \beta_3 D_2 + \gamma_1 E_1 + \gamma_2 E_2 + \varepsilon$$

where $E_1 = 1$ iff "renters; 0 otherwise.

$E_2 = 1$ iff "other; 0 otherwise

$B_1 = E_1 \cdot \ell n\, Y_j, B_2 = E_2 \cdot \ell n\, Y.$

$D_1 = E_1 \cdot \ell n\, C_j, D_2 = E_2 \cdot \ell n\, C.$

APPENDIX B

As a result of the 1960 Survey of Consumer Expenditure by the Bureau of Labor Statistics a data file containing 13,732 observations on household expenditures and characteristics was created.[10] The original data included 379 separate classifications of consumer expenditure; in a summary file the number of classifications was reduced to 140. The file available for this study represents an alignment of these 140 categories with the 80 order I/O model.[11] Expenditure on each of the 140 categories is allocated to one or more of the 56 input-output sectors used in this study. The input-output sectors and their respective inverse coefficients with respect to the logging sector are listed in Table B-1. Details of the alignment method are reported in Table B-2.

Each observation now contains the dollar amount of 1960 expenditure on each of the 56 categories of final demand and a list of socioeconomic variables. Households have been eliminated from the study if they have nonpositive income, are listed as composed of zero numbers, or are institutionalized individuals. A total of 556 observations were eliminated by these criteria.

Included in this list of variables is an expansion factor (n) which is the BLS' estimate of the number of households in the entire population which are represented by a particular observation. In performing the tabulations described above each observation read from the file is treated as n identical observations in accordance with the expansion factor.

One of the variables for each observation is the accounting balance difference. It is calculated as reported money receipts minus reported

expenditures minus the change in net assets. An initial tabulation was performed using the reported data. Subsequent tabulations (including all those reported here) were performed using adjusted data. One third of the accounting balance difference is allocated to income and one third is allocated to expenditure. Specific expenditure categories were changed in proportion to their shares in the household's total expenditures. Casual observation reveals no difference in the patterns between the tabulations using adjusted and unadjusted data.

One difficulty encountered in analyzing a cross section survey of current incomes arises from the difference between the distribution of current incomes and the distribution of permanent incomes. Suppose current income for each household equals permanent income plus a random variable, which represents the effect of transitory phenomena: temporary unemployment, sickness, inheritances, etc. If the distribution of permanent income is roughly bell shaped, then it is likely that the distribution of current income will have thicker tails than the permanent income distribution, i.e. more households in the lowest and highest income classes. The reason is that more households are temporarily in a very low income bracket than are temporarily in the next highest bracket; and more people are temporarily in the very highest bracket than are temporarily in the next lowest bracket. The more central brackets of the permanent income distribution, having more people than the extreme brackets, tend to lose more to transitory phenomena, than the extreme brackets do.

Individuals who are temporarily in a low income bracket tend to consume a larger amount than is warranted by their current income. As a result

impact measures calculated from current consumption expenditures are large relative to current income. This effect is apparent in the first column of each of Tables I-VI. The ratios of impact to after tax income for the lowest income class are very large in comparison with other income classes. For this reason the calculations for the lowest income class should be regarded with great caution.

Table B-1

CONSUMER EXPENDITURE SECTORS AND INPUT-OUTPUT COEFFICIENTS

Sector #	Coefficient	Sector Title
1	.00181	Livestock and livestock products
2	.00277	Other agricultural products
3	.00063	Forestry and fishery products
7	.00922	Coal mining
12	.00535	Maintenance & repair construction
13	.00474	Ordnance & accessories
14	.00324	Food & kindred products
15	.00232	Tobacco manufactures
16	.00243	Broad & narrow fabrics, yarn & thread mills
17	.00249	Misc textile goods & floor coverings
18	.00177	Apparel
19	.00349	Misc fabricated textile products
20	.19008	Lumber & wood products, except containers
22	.03530	Household furniture
23	.01251	Other furniture & fixtures
24	.03631	Paper & allied products, except containers
25	.05556	Paperboard containers & boxes
26	.01459	Printing & publishing
27	.00650	Chemicals & selected chemical products
28	.00397	Plastics & synthetic materials
29	.00463	Drugs, cleaning & toilet preparations
30	.00227	Paints & allied products
31	.00092	Petroleum refining & related industries
32	.00276	Rubber & misc plastic products
34	.00385	Footwear & other leather products
35	.00516	Glass & glass products
36	.00318	Stone & clay products
38	.00218	Primary nonferrous metal manufacturing
41	.00245	Stampings, screw machine products, & bolts
42	.00377	Other fabricated metal products
43	.00133	Engines & turbines
44	.00178	Farm machinery & equipment
51	.00088	Office, computing & accounting machines
54	.00341	Household appliances
55	.00285	Electric lighting & wiring equipment
56	.00595	Radio, television & communication equipment
57	.00200	Electronic components & accessories
58	.00183	Misc electrical machinery, equipment & supplies
59	.00147	Motor vehicles & equipment
61	.01476	Other transportation equipment
62	.00320	Scientific & controlling instruments
63	.00216	Optical, ophthalmic & photographic equipment
64	.00758	Misc manufacturing
65	.00066	Transportation & warehousing
66	.00060	Communications, except ratio & TV broadcasting
68	.00099	Electric, gas, water & sanitary services
69	.00124	Wholesale & retail trade
70	.00148	Finance & Insurance

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Sector #	Coefficient	Sector Title
71	.02106	Real estate & rental
72	.00158	Hotels; personal & repair services, except auto
73	.00096	Business services
75	.00086	Automobile repair & services
76	.00087	Amusements
77	.00085	Medical, educational services & nonprofit organizations
78	.00032	Federal government enterprises
79	.00169	State & local government enterprises

TABLE B-2

Alignment of Consumer Expenditure Categories
With Input-Output Sectors

Consumption Category		Percent	Input-Output Sector Numbers
Food and Alcoholic Beverages		3.0	1
		4.9	2
		.8	3
		87.8	14
		.2	65
		.5	69
		2.8	80
Tobacco		98.7	15
Housing, total			
Shelter, total			
Rented dwelling		.7	7
		4.5	31
		6.0	68
		88.8	71
Owned dwelling, total			
Interest on mortgages and Other Expenses		100.0	70
Property insurance		100.0	70
Repairs and replacements		50.0	12
		50.0	30
Owned vacation home, cabin, etc.		25.0	12
		25.0	30
Lodging out of home city		95.0	72
		5.0	77
Other real estate		100.0	71
Fuel, light, refrigeration and water, total			
Solid and petroleum fuels	NE	11.0	7
		1.8	20
		87.2	31
	NC	21.0	7
		2.4	20
		76.6	31
	S	27.5	7
		10.0	20
		62.5	31
	W	9.4	7
		8.5	20
		82.1	31
Gas and electricity		100.0	68
Water, sewage, garbage, and trash collection		93.5	68

TABLE B-2 (cont.)

Consumption Category	Percent	Input-Output Sector Numbers
Ice, water softening services, freezer rentals, etc.	33.0	14
	33.0	65
	34.0	73
Household operations, total		
Telephone and telegraph	100.0	66
Other household services		
Under $15,000 inc. after taxes	40.0	72
	20.0	65
	20.0	86
$15,000 or over	66.0	86
	34.0	72
Household supplies	2.2	14
	20.7	24
	1.2	25
	7.2	26
	5.9	27
	1.4	28
	49.1	29
	1.4	36
	2.3	38
	8.6	78
Housefurnishings and equipment, total		
Household textiles	31.0	16
	1.0	17
	64.0	19
	1.0	32
	2.0	54
Furniture, total	98.0	22
	2.0	83
Floor coverings	75.0	17
	25.0	64
Major appliances, total	100.0	54
Small appliances	100.0	54
Housewares, total	10.0	19
	4.0	20
	14.0	32
	11.0	35
	10.0	36
	17.0	41
	8.0	42
	21.0	64
	6.0	80
Insurance on furnishings, equipment, and apparel	100.0	70

TABLE B-2 (cont.)

Consumption Category	Percent	Input-Output Sector Numbers
Other	4.5	20
	7.0	23
	6.0	34
	7.0	36
	13.2	42
	19.4	44
	7.0	51
	23.3	55
	5.0	62
	8.0	64
Clothing, clothing materials, and clothing services, total		
Clothing, total	94.0	18
	3.0	34
	2.0	80
Footwear, total	10.0	32
	88.0	34
	2.0	80
Jewelry and watches, total	3.0	34
	14.3	62
	79.0	64
	2.2	80
	1.5	83
Clothing materials	100.0	16
	100.0	72
Transportation, total		
Automobile purchase	89.0	59
	11.0	83
Automobile operation		
Gasoline, motor oil	100.0	31
Other auto operation	21.0	32
	4.0	58
	3.0	59
	67.0	75
	4.0	79
Public transportation, car pools, other	50.0	65
	3.0	31
	5.0	43
	31.0	61
Medical care, total		
Prepaid care (premiums)	11.0	70
	89.0	77

TABLE B-2 (cont.)

Consumption Category	Percent	Input-Output Sector Numbers
Services		
Direct expenses, total	100.0	77
Eye care, including glasses	100.0	63
Drugs and medicines	100.0	29
Medical appliances, supplies, other	8.0	32
	24.0	62
Personal care, total		
Services	100.0	72
Supplies	14.0	24
	73.0	29
	6.0	42
	3.0	54
	4.0	64
Recreation, total		
Television and Radio, phonographs, musical instruments, etc.	65.0	56
	8.0	57
	6.0	64
	20.0	72
Spectator admissions	100.0	76
Participant sports (equip., fees, dues) and club dues, hobbies, pets, toys, recreation out of home city, other	7.0	13
	16.0	63
	36.0	64
	21.0	76
	18.0	77
Reading	100.0	26
Education		
Tuition and fees and music and other special lessons	100.0	77
School books, supplies, equipment	69.0	26
	31.0	64
Miscellaneous personal consumption expenditures (.3 of this category has been allocated as follows)	32.0	14
	38.0	72
	24.0	65
	6.0	76
Personal insurance, total, nongovernmental	100.0	70

TABLE B-2 (cont.)

su .on Category	Percent	Input-Output Sector Numbers
ts and contributions, total (cash, goods, ervices)		
To persons not in family (.67 of this category has been allocated as follows	4.0	2
	64.0	14
	16.0	18
	4.0	26
	5.0	29
	4.0	54
	4.0	64
To organizations	100.0	77
ue of home produced food	31.0	1
	28.0	2
	41.0	14

FOOTNOTES

[1]Investigations of the relationship between supply and price include Adams (1972), Adams and Blackwell (1971), Dutrow (1971), Hamilton (1970), Marty (1973), McKillop (1967, 1969), Mead (1966), Mills (1975), Mills and Manthy (1974), Robinson (1974), Teeguarden and McKillop (1969), USDA (1973) and Zivnuska (1955).

[2]For a mathematical treatment of welfare loss see Henderson and Quandt (1971), pp. 23-29. For further discussion see Hicks (1968), pp. 38-41.

[3]Note however that it is not the only well defined measure. One instead could use the lump sum tax ($x) which, applied to the original situation, would leave the household exactly as well off as after the price change. In general $\$x \neq \$y$. For further discussion see Samuelson (1971), pp. 197-202.

[4]The measure is also applicable to a decrease in a commodity price. In that case the compensating variation is the amount of income that would have to be taken away so that the household would be just as well off after the price decrease as before.

[5]A sensitivity test on this assumption is performed in Section IV.

[6]Some evidence is presented in Reid (1962), Maisel and Winnick (1960), Morgan (1965), and Lee (1962).

[7]Excellent treatments of input-output theory are presented in Dorfman, Samuelson and Solow (1958), Chapters 9 and 10, and Intrilligator (1971), Chapter 9, Section 2.

[8]The 80-order version is published in Survey of Current Business, February, 1974. The larger version is in USDC (1974).

[9]See Cliff (1973), pp. 2-8.

[10]See USDL (1966).

[11]The alignment was performed by the staff of the Institute for Research on Poverty at the University of Wisconsin.

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In each model the dependent variable is the natural logarithm of the impact measure, IMP1. All of the models include the age classification variable and the same variable squared. They are included in an attempt to account for the life cycle pattern of income discussed previously in connection with Tables III and V. Model 1A includes in addition the natural logarithm of income as an explanatory variable. The coefficient β_1 in model 1A is therefore the elasticity of the impact with respect to income; the impact is termed regressive/proportionate/progressive according to whether $\beta_1 < / = / > 1$.

Model 1B includes in addition two dummy variables, E_1 and E_2, to capture the effect of each of the three classes of tenure. E_1 equals one if and only if the household is a "renter"; otherwise it equals zero. E_2 equals one if and only if the household is an "other"; otherwise it is zero. The value of the constant (const) reported in Table VI for model 1B applies only to homeowners. The value of the constant for renters is const plus γ_1, and for "others" the value is const plus γ_2.

Model 1C includes two more dummy variables, B_1 and B_2, which allow the slope coefficients on income to also vary by class of owner-renter status. Variable B_1 equals ℓnY if and only if the household is a renter; otherwise it is zero. Variable B_2 equals ℓnY if and only if the household is an "other"; otherwise it is zero. The elasticity estimate β_1 in model 1C is that for homeowners only. The estimate for renters is β_1 plus β_2; for "others" the estimate is $\beta_1 + \beta_3$.

Models 2A, 2B, and 2C are exactly the same as the first three models except that the natural logarithm of consumption expenditures replaces the

TABLE V(a)

IMPACT, VARIANT 1, BY AGE AND INCOME CLASS, FOR OWNERS

Income- $\$10^3$

Age	0-1	1-2	2-3	3-4	4-5	5-6	6-7.5	7.5-10	10-15	15-25	> 25	ALL
< 25	.00 - - -	.00 - - -	* 10.6 .37 .31	* 13.1 .37 .43	.13 14.6 .32 .30	.11 18.5 .32 .36	* 22.9 .30 .36	* 21.6 .26 .34	* 33.6 .23 .28	.00 - - -	.00 - - -	.38 17.4 .33 .34
25-34	* 4.2 .42 .38	* 8.1 .48 .33	.10 10.5 .40 .38	.43 12.1 .33 .34	.88 15.4 .32 .34	1.27 18.8 .33 .35	1.52 21.4 .31 .35	.96 26.8 .30 .35	.27 33.9 .30 .36	* 41.4 .24 .46	* 39.8 .10 .41	5.55 20.4 .32 .35
35-44	* 6.5 6.64 .37	.24 8.2 .48 .36	.48 10.6 .39 .35	.71 14.1 .38 .36	1.25 15.8 .33 .35	1.76 17.5 .31 .33	3.20 21.6 .31 .34	2.68 26.6 .30 .35	.95 35.5 .30 .36	.15 42.9 .23 .34	* 58.3 .18 .33	11.52 21.7 .36 .35
45-54	.19 5.8 1.15 .40	.37 8.1 .50 .35	.78 9.7 .38 .35	1.17 13.4 .38 .35	1.39 15.1 .33 .34	1.81 17.7 .31 .34	2.37 20.9 .30 .34	2.46 25.3 .29 .34	1.22 33.4 .28 .34	.26 44.1 .24 .33	* 67.8 .22 .32	12.05 20.5 .33 .34
55-64	.42 4.9 1.03 .36	1.18 7.0 .45 .36	1.18 9.1 .36 .35	1.04 12.4 .35 .35	1.57 14.3 .31 .35	1.31 16.2 .29 .34	1.50 19.9 .29 .34	1.24 24.4 .28 .34	.66 29.6 .25 .33	.13 41.5 .23 .31	* 59.0 .16 .32	10.26 16.0 .35 .34
65-74	.62 3.8 .57 .38	2.50 6.2 .41 .36	2.20 9.7 .38 .37	1.89 11.7 .33 .35	1.13 14.5 .32 .35	.61 16.8 .30 .35	.66 20.1 .30 .36	.50 21.1 .25 .32	.31 30.5 .26 .34	* 52.6 .30 .38	* 67.1 .20 .33	10.56 12.2 .36 .36
$\geq$ 75	.82 3.3 1.11 .37	1.55 5.6 .37 .36	1.19 8.7 .35 .36	.47 10.1 .29 .34	.21 12.3 .27 .34	.24 16.3 .29 .35	.14 23.6 .32 .36	.16 22.2 .28 .35	* 29.7 .24 .34	* 71.8 .35 .51	* 33.7 .10 .23	4.89 9.0 .47 .35

*Indicates less than .1%.

TABLE b)

IMPACT, VARIANT 1, BY AGE AND INCOME CLASS, FOR RENTERS

Income- $\$10^3$

Age	0-1	1-2	2-3	3-4	4-5	5-6	6-7.5	7.5-10	10-15	15-25	> 25	All
< 25	* 16.5 3.09 .85	.49 12.3 .78 .69	.70 16.1 .63 .63	.81 22.0 .61 .61	.61 26.4 .57 .59	.41 33.2 .60 .62	.24 38.1 .56 .62	* 39.4 .48 .56	.00 - - -	* 42.6 .22 .71	.00 - - -	3.38 23.1 .65 .63
25-34	* 5.1 .66 .52	.73 12.6 .75 .66	1.33 16.3 .63 .61	1.65 22.4 .63 .61	2.06 26.1 .57 .58	1.37 30.0 .53 .56	1.00 36.5 .54 .57	.57 43.4 .50 .58	* 50.1 .43 .50	* 59.3 .35 .59	* 77.5 .27 .54	8.89 25.8 .59 .59
35-44	.14 8.0 1.26 .50	.70 10.8 .68 .63	1.03 16.0 .62 .58	1.37 21.1 .59 .58	1.46 25.4 .56 .57	1.14 29.0 .52 .55	.97 33.8 .50 .54	.57 42.2 .49 .55	.27 54.2 .46 .52	* 59.5 .32 .46	.00 - - -	7.67 25.6 .57 .57
45-54	.27 6.5 .82 .64	1.00 12.1 .81 .71	1.24 16.4 .64 .63	.96 21.0 .59 .60	.94 24.1 .53 .56	.76 28.4 .51 .54	.87 33.6 .49 .52	.61 37.4 .44 .51	.31 51.6 .42 .48	* 70.3 .37 .45	.00 - - -	6.97 24.1 .59 .59
55-64	.54 6.7 1.00 .74	1.17 11.2 .74 .72	1.04 16.3 .66 .65	.77 20.9 .58 .60	.87 23.6 .52 .57	.48 27.7 .50 .55	.29 32.3 .48 .56	.44 39.5 .47 .54	.20 51.1 .44 .50	* 74.8 .44 .58	* 77.0 .28 .45	5.80 21.0 .63 .63
65-74	.66 6.6 .82 .73	2.07 12.2 .82 .77	1.22 18.3 .74 .73	.71 22.2 .65 .69	.43 24.8 .56 .62	.36 27.3 .50 .59	.11 28.0 .42 .47	.13 40.0 .45 .58	* 45.2 .39 .48	* 76.0 .33 .49	.00 - - -	5.79 17.5 .72 .71
≥ 75	.73 7.0 .91 .79	1.39 11.4 .81 .79	.43 17.7 .73 .73	.20 22.8 .68 .73	* 23.6 .53 .59	* 27.1 .49 .71	* 33.3 .48 .67	* 39.9 .50 .63	* 57.3 .47 .52	.00 - - -	.00 - - -	3.03 13.7 .79 .77

*Indicates less than .1%.

natural logarithm of income wherever the latter variable appears in the first models.

The estimates (see Table VI) of models 1A and 2A suggest that the overall distributive effect is regressive. Equation 1A implies that, controlling for age, an increase in income of 1 percent results in an increase of 0.62 percent in impact. Equation 2A implies that, controlling for age, an increase in consumption expenditures of 1 percent results in an increase in impact of 0.84 percent.

Models B and C attempt to discover how much of the regressivity is accounted for by the (negative) correlation between income and home ownership. Models 1B and 2B allow the constant term to vary across tenure classifications while effectively constraining the elasticity estimates to be equal. The increase in explanatory power of the regression is substantial in both cases; F-tests indicate that the dummy variables are significant in both models at the .0001 level.

The difference in impact between the tenure classifications is revealed as follows. For households in the same age classification and with the same income (consumption expenditure), the estimated impact on "renters" and "others" are respectively, exp $\{\gamma_1\}$ and exp $\{\gamma_2\}$ times the impact on homeowners. Controlling on age and income (consumption expenditure), renters have an estimated impact that is 65 percent (68 percent) greater than owners. Similarly "others" have an estimated impact that is 46 percent (36 percent) greater than owners.

The estimates of β_1 rise in both models 1B and 2B from models 1A and 2A. Controlling on age and tenure, a 1 percent increase in income (consumption expenditures) results in an increase of .71 percent (.94 percent) in estimated impact.

TABLE VI

REGRESSION ESTIMATES

MODEL	CONST	AGE	AGE^2	ℓnY	B_1	B_2	ℓnC	D_1	D_2	E_1	E_2	R^2
1A	-2.00	-.11	.004	.623								.57
	(40)	(9)	(2.8)	(108)								
1B	-3.25	.02	-.006	.710						.50	.38	.69
	(70)	(1.6)	(4.4)	(140)						(69)	(21)	
1C	-3.20	.02	-.006	.704	.031	-.154				.24	1.71	.69
	(58)	(1.7)	(4.5)	(113)	(3.2)	(5.6)				(3)	(7)	
2A	-3.77	-.17	.016				.843					.72
	(82)	(18)	(13)				(156)					
2B	-5.15	-.04	.006				.944			.52	.31	.84
	(141)	(6)	(6)				(231)			(105)	(26)	
2C	-5.47	-.05	.007				.984	-.100	.015	1.35	.18	.84
	(123)	(7)	(7)				(193)	(13)	(.6)	(22)	(.9)	

Figures in parentheses are the absolute value of the t-statistics.

E_1 = 1 if "renter"; 0 otherwise

E_2 = 1 if "other"; 0 otherwise.

$B_1 = E_1 * \ell nY$; $B_2 = E_2 * \ell nY$.

$D_1 = E_1 * \ell nC$; $D_2 = E_2 * \ell nC$.

See text for further explanation.

Models 1C and 2C allow both the constant term and elasticity to vary across tenure classifications. The additional dummy variables increase the R^2 only marginally, although the associated F=test is still significant in both cases at the .0001 level. The estimates imply that, controlling for age, a 1 percent increase in income (consumption expenditure) results in a .70 percent (.98 percent) increase in estimated impact for owners and a .73 percent (.88 percent) increase in estimated impact for renters. If consumption expenditure is taken to be the preferred proxy for permanent income, then Model 2C suggests that within each tenure classification the measured impact is only slightly regressive.

Table VII presents a third measure of impact, IMP3, which is based on expenditures for all commodities except housing. The rational is as follows: The results in Table I show that average impacts decline as a percentage of income as income increases. However, Tables IV and V show that the pattern of impacts is substantially influenced by the relationships between income and homeownership, and between homeownership and impact. (All payments to sector 71, real estate and rental, have been eliminated in the calculation of IMP3.)

The categories of Table VII are the same as those in Table I. Several points are noteworthy. Average impacts in Table III are less than those in Table I by about $5-6. The same pattern of monotonic increase with income class is observed. Average ratios of impact to income decline as income class increases; however the decline is much less marked than in Table I. Average ratios of impact to consumption expenditures are almost constant across income classes. Our finding is that, apart from expenditures on

TABLE VII

IMPACT, VARIANT 3, BY INCOME CLASS

Income- $\$10^3$

Age	0-1	1-2	2-3	3-4	4-5	5-6	6-7.5	7.5-10	10-15	15-25	> 25	All
% Household	4.65	13.6	13.2	12.5	13.5	12.2	13.6	10.9	4.5	.75	.19	100.0
IMP3	3.26	5.34	8.36	11.5	13.9	16.7	20.1	24.4	31.8	42.2	56.1	14.6
IMP3/Y (%)	.82	.34	.33	.32	.30	.30	.29	.28	.27	.23	.17	.33
IMP3/C (%)	.31	.31	.32	.32	.32	.32	.33	.33	.33	.32	.32	.32

INCOME is after tax household income.

%HH is the percentage of households tabulated belonging to each category.

IMP3 is the measure of impact on households, variant 3, average for each category.

IMP3/Y is the measure of impact as a percentage of INCOME, average for each category.

IMP3/C is the measure of impact as a percentage of household consumption expenditures, average for each category.

housing, the impact of a change in timber prices is close to being proportional to income or expenditure.

Life Cycle Considerations

It should be emphasized that the calculations presented in these tables are valid for a household only so long as it remains in a particular age-housing status-income category, and the calculations are valid only at the time of the price changes. A household which is an owner at the time of a price increase will not be affected by a change in the price of housing only so long as it continues to consume the same quantity of housing. Future reductions or increases in the quantity of housing consumed that would have taken place even in the absence of a price change -- because the household ages, and changes in size, etc. -- will yield extra benefits or burdens as a result of the price change. For example a household may at one age own a small house, and later move to a larger dwelling when there are children present, and still later return to a small house. If an increase in the price of housing occurs during the first stage, the homeowner is not immediately affected, but the household must pay a premium at a later time when a larger house is desired.

In order to represent these life-cycle aspects of the problem a simple example has been constructed. Figure 3 displays three possible paths for housing consumption as age increases. The shape of these paths is derived from a cursory inspection of some of the economic literature on housing consumption.[6] On each of the paths, housing consumption is assumed to rise by 20 percent between each of the first four age categories, 18-24, 25-34, 35-44, and 45-54. Consumption is assumed to be 5% greater between ages 55 and 74 than 45-54, and then declines by 10% for ages 75-84. Path 1 represents an annual consumption of $1000 of housing in the ages 18-24, rises to a maximum of $1810 and then declines to $1630.

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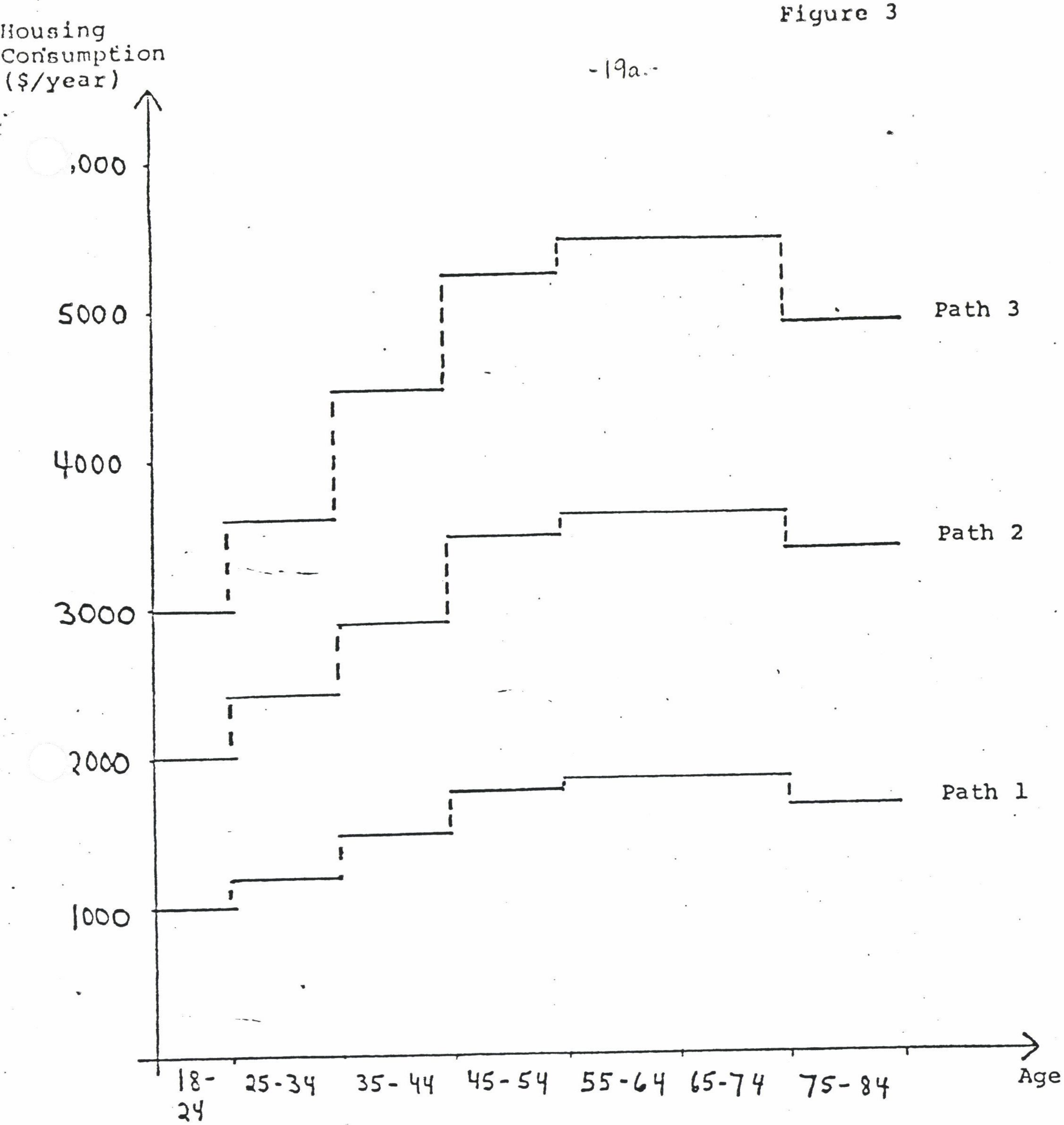
Figure 3



Three Hypothetical Paths of Life Cycle Housing Consumption

TABLE VIII

LIFE CYCLE ASPECTS

THE AVERAGE ANNUAL LIFETIME IMPACT OF a 3% INCREASE IN THE PRICE OF HOUSING

	PATH 1		PATH 2		PATH 3	
Age	Renter	Owner	Renter	Owner	Renter	Owner
17	43.12	15.12	86.38	30.38	129.47	45.47
24	44.88	11.28	89.94	22.74	134.76	33.97
34	47.15	6.83	94.47	13.83	141.57	20.61
44	48.86	.42	97.94	1.05	146.72	1.68
54	49.00	-1.68	98.28	-3.36	157.36	-5.04
64	48.16	-2.52	96.60	-5.04	144.76	-7.56
74	45.64	0	91.56	0	137.20	0

Paths 2 and 3 have initial consumption of two and three thousand dollars respectively, rise to maximums of \$3630 and \$5440, and then decline to \$3270 and \$4900.

Table VIII analyzes the implications of these paths for households which are renters and owners of different ages at the time of the price increase. Each entry in Table VIII is the average extra amount per year that a household would have to pay in order to stay on its planned housing consumption curve to age 84. For example a price increase coming at age 17 for an owner on path 1 implies that the household must pay out an average of \$15.12 extra per year during the years 18-84. (The magnitude of price increase for housing used here is 3%. A doubling or halving of this magnitude results only in a doubling or halving of the entries in the table.)

The results for each of the 3 paths are similar in their qualitative properties. Renters must pay the full amount of any price increase for the rest of their lives. Owners, however, need only pay for any additional amount of housing consumed in later years. Indeed an owner who is consuming the maximum amount of housing receives a net benefit from the price increase. This benefit accrues as a realized capital gain when the owner moves to a smaller house.

V. Summary and Conclusion

This study has investigated the distributional impact of changes in the supply of timber that result in once-and-for-all changes in prices. The study is confined to analyzing the impact of such price changes; the link between decisions variables available to the U.S.F.S. and the price of logs must also be established in order to analyze the impact of any U.S.F.S. decision.

This study makes use of the input-output tables developed by the Department of Commerce in order to translate changes in the price of logs into changes in the prices which consumers pay for the commodities they purchase. Use of the input-output model has enabled us to recognize the complex manner in which timber products are directly and indirectly utilized in the provision of consumer goods. However, the input-output approach also has severe limitations; most important is that it fails to recognize possibilities of factor substitution in production. Hence the implications of the input-output model become less realistic the longer is the period of time under consideration. During a period in which industry would find it extremely expensive to alter its production processes, such as the time it takes for existing machines to wear out, the input-output model is a very useful approach. For periods of 10 years or more, however, its usefulness is much more restricted.

The impact on households of consumer price changes has also been examined under fairly strict assumptions. The results, however, seem fairly robust with respect to at least the exact parameterization of compensated demand curves. More difficult is the problem of assessing to what extent changes in the price of new housing affect the price of existing housing. The key findings of this study, overall regressivity of impacts, and the renter/owner differential, hinge upon the assumption that the price of existing housing responds significantly to the cost of new housing. Further study of this aspect of the problem may be warranted; however we feel that the qualitative nature of the results is likely to prove robust under further scrutiny.

Appendix A

Use of the Input-Output Tables

The production functions underlying an input/output matrix are of the form[7].

$$X_j = \min_i \frac{X_{ij}}{a_{ij}} \qquad i=1, \ldots, n; \; j=1, \ldots, n \tag{A.1}$$

where X_j is the output rate of sector j,

X_{ij} is the input rate from sector i to sector j

and a_{ij} is a constant.

If production is efficient, the relation (A.1) holds with equality in every case, that is

$$a_{ij} = \frac{X_{ij}}{X_j} \qquad i=1, \ldots, n; \; j=1, \ldots, n \tag{A.2}$$

The a_{ij} are ratios of real quantities; a_{ij} is the amount of input i required in the production of a unit of output j. In empirical work, however, the real values are proxied by nominal values; thus the sales from industry i to industry j are divided by the dollar value of industry j's output.

$$a^*_{ij} = \frac{P_i X_{ij}}{P_j X_j} = \frac{P_i}{P_j} a_{ij} \tag{A.3}$$

The resulting ratios measure the dollar amount of input i required to produce one dollar of output j. The relationship between the matrix $A = \{a_{ij}\}$ and the matrix $A^* = \{a^*_{ij}\}$ is

(A.4) $$A^* = I_p\, A\, I_p^{-1}$$

where $$I_p = \begin{bmatrix} P_1 & & & \\ & P_2 & & 0 \\ & & \ddots & \\ 0 & & & P_n \end{bmatrix}$$

The direct and indirect requirements matrix in dollar values is similarly related to the direct and indirect requirements matrix in real terms.

(A.5) $$(I-A^*)^{-1} = I_p\, (I-A)^{-1}\, I_p^{-1}$$

For convenience write the respective inverse matrices as B and B*.

(A.6) $$B \overset{\text{def}}{=} (I-A)^{-1}$$

$$B^* \overset{\text{def}}{=} (I-A^*)^{-1} = I_p\, B\, I_p^{-1}$$

Under the assumption that firms make zero profits, the price of product j is determined by the prices and quantities of intermediate products consumed in production, and by the value added per unit of output.

(A.7) $$P_j = \sum_i a_{ij} P_i + V_j$$

Value added may be considered to include the dollar value of labor, capital, and other non-produced factors required per unit of output. The expression (7) for the economy as a whole is

(A.8) $$P = A'P + V$$

where $P' = (P_1, P_2, \ldots, P_N)$

$V' = (V_1, V_2, \ldots, V_N)$

and A' is the transpose of A.

It follows that

(A.9) $$P = (I-A')^{-1}V = B'V$$

$$P_j = \sum_i B_{ij} V_i$$

The price of each commodity ultimately depends only on the value of non-produced factors used directly and indirectly in its production. That is, value accrues to a produced commodity only to the extent that it embodies scarce factors.

Now suppose the dollar value of resources required per unit of output in a particular sector i' is increased by an amount $\Delta V_{i'}$, value added in all other sectors being held constant. For the purposes of this study, take i' to be the logging sector, 20.01, and suppose that an increase in the price of stumpage is the actual cause of $\Delta V_{i'}$. The interpretation of an increase in value added as resulting from an increase in stumpage prices is very loose. Changes in stumpage prices will affect the cost of logging sector inputs, not value added. However the purpose is to raise the price of forest output at as early a stage of processing as possible, in order to capture the interactions between sectors. An alternative and technically correct interpretation is that $\Delta V_{i'}$ results from imposition of an excise tax on the logging sector output, and that the tax is borne entirely by consumers.

Each output j will then increase in price according to its use, directly and indirectly, of the commodity i'.

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$$\Delta P_j = B_{i'j}\,\Delta V_{i'} = \frac{P_j}{P_{i'}}\,B^{*}_{i'j}\,\Delta V_{i'} \tag{A.10}$$

If the change in the rate of value added in sector i' is expressed as a proportion r of the price of sector i' output, then the proportionate change in the price of each output j is very easy to compute.

$$\frac{\Delta P_j}{P_j} = B^{*}_{i'j}\,r \tag{A.11}$$

In this study r has been set equal to one. Since the total requirements coefficient for the logging sector with respect to itself is approximately 1.08, this example implies an increase of about 108% in the price of logging sector output.

The linearity of the production relations and the method of estimating welfare impacts insures that the choice of a value for r will affect only the magnitude of the impact on households, and not the relative values among households. Since it is relative impacts with which this study is concerned, the particular magnitude chosen for the price increase is not important. However, it is useful to suggest the relationship between stumpage and logging sector prices. The input-output table indicates that approximately 33% of the price of logging sector output is accounted for by the price of stumpage. This figure may be somewhat low due to underreporting of stumpage values by firms which integrate growing and harvesting operations. Taking 33% as a benchmark figure, however, we can calculate that the price of stumpage would need to increase about 4 1/4 fold to produce this rise in the price of logs.

The values of the B matrix used in this study are taken from the Department of Commerce's input-output study for 1967 with certain modifications. The Commerce Department study classifies the U.S. economy into

367 sectors and 10 categories of final demand. A more aggregated version reduces the 367 order matrix to an 80 order matrix.[8] The consumer expenditure data (see Appendix B) are aligned with 56 of the latter sectors. Ideally the analysis would be carried out by increasing the price of stumpage. However in both the 367 and 80 order classifications stumpage values are recorded in sector 3.00, Forestry and Fishery Products. Using the inverse coefficients for final demand with respect to sector 3.00 would result in also increasing the prices of commodities which use fishery products. However, all forest outputs of sector 3.00 are recorded as passing through the logging sector, 20.01, before being used by the other processing sectors. The inverse coefficients for the 56 categories of consumer demand with respect to the logging sector are obtained by computing, for each category, a weighted average of the subcategory coefficients where the weights are the shares of the subcategories in the category sales to the personal consumption expenditure classification of final demand. For example, the household furniture sector, 22, consists of four subsectors, 22.01-22.04. The coefficient of sector 22 with respect to logging is the weighted sum of the subsector coefficients with respect to logging. The relevant weight for subsector 22.01 is the ratio of its sales to personal consumption expenditure to the total sales by all subsectors of 22 to personal consumption expenditure.

Two other modifications were made to the coefficients. The new residential construction sector (11.01) is treated in the I/O studies as selling all of its output to the final demand category "gross private fixed capital formation" since residences are classified as capital goods. Rental payments are classified as being made to the real estate and rental sector (71), but the cost of residences is not reflected in the sector 71

coefficient with respect to logging because capital goods flows are outside the matrix.

Initial work on this study used the coefficient for residential construction to compute increases in rents. However two factors suggest that rents on existing housing would not rise fully in proportion to the costs of new housing. First, existing housing is an imperfect substitute for new housing, and second site values and maintenance costs are included in rents. Thus rental rates on existing housing are expected to rise less than proportionally to the cost residential construction. The calculations presented in this study were accomplished by multiplying the residential construction coefficient by .75 and using the resulting figure to estimate increases in rental rates.

The third modification is to use the coefficient for maintenance and repair construction, residential buildings, (12.01) for the coefficient with respect to the entire maintenance and repair construction sector (12). The former coefficient is clearly more appropriate for consumer expenditures than is the aggregate coefficient for sector 12.

A significant problem with the input-output table arises from the importance of international trade in forest products. The U.S. in 1970-72 had net imports of about 11% of total domestic consumption of wood products.[9] Most imports are allocated to a later stage of processing than logging, and this causes the coefficients of final demand commodities with respect to logging to be biased downwards. That is, the coefficients in the input-output table account for domestically supplied and imported logs, but not the logs from which imported paper and lumber are manufactured.

It is expected that any policy action which changes the price of domestic logs is also likely to alter foreign (especially Canadian) prices. A change in the price of imported products is, however, no where recognized in the calculations.

The principal effect of this omission is to bias downward the price increases of commodities which depend on imports of wood products, and hence also the impacts on households. This bias is only relevant to our comparisons between households if some households consume substantially more of the commodities which utilize imports than do other households. It seems unlikely that there is any systematic relationship between the biases of the coefficients and the consumption patterns of households in different income classes; and hence we do not expect the significant biases are introduced into analysis of the distribution of impacts.

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